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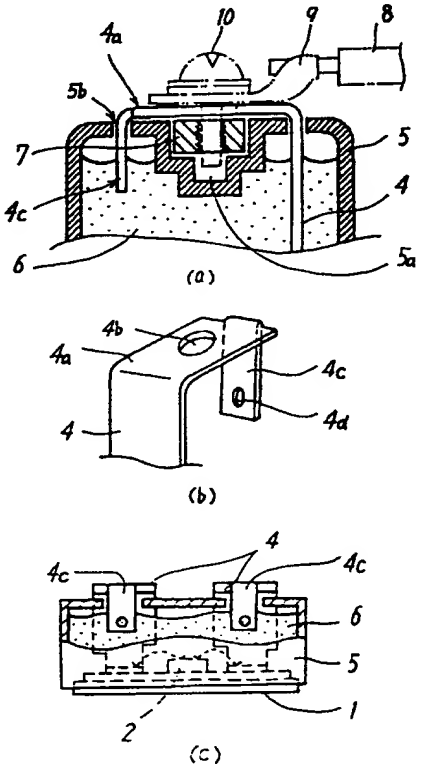
(54) Resin-sealed semiconductor device.

(57) A circuit assembly is sealed in an outer casing (5) filled with a sealing compound (6). A terminal (4) for an external wiring connection to the circuit assembly is bent into an L shape with one leg provided outside of the casing and forming an external wiring connection portion (4a) and the other leg extending into the casing and connected to the circuit assembly. The wiring connection portion (4a) is superimposed on a terminal nut (7) provided in a recess (5a) on the casing top. An anchor portion (4c) bent downward is disposed at the free end of the external wiring connection portion (4a) the tip of the anchor portion being inserted into the casing (5), embedded in the sealing compound (6), and fixed there. By means of this construction the support strength of the wiring connection portion (4a) of the terminal (4) is improved.

FIG. 1



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The present invention relates to a resin-sealed semiconductor device, such as a diode, thyristor or transistor module, and, more particularly, to the structure of a terminal thereof used for connecting an external wiring to the device.

Figs. 9(a) to (c) and 10 show a conventional resin-sealed semiconductor device and its terminal structure. In the figure, numeral 1 represents a heat dissipating metal base, 2 an insulating substrate, 3 a semiconductor chip, 4 a terminal, 5 an outer casing made of resin, 6 a sealing compound such as epoxy resin that fills the casing, and 7 a terminal nut mounted in a respective recess 5a on top of the outer casing 5. The figures actually show two terminals 4, two nuts 7, two recesses 5a etc. the number depending on the kind of semiconductor device. For ease of explanation, in the following description of the prior art and the invention reference will be made to one terminal only and it goes without saying that the same applies to all terminals.

The terminal 4 comprises a lower part disposed inside the casing 5 and an upper part disposed outside the casing and forming a wiring connection portion 4a. The wiring connection portion 4a is bent to be substantially parallel to the top of the casing 5.

A semiconductor device with such a construction is assembled in the following manner. First, the semiconductor chip 3 and the terminal 4 which has not yet been bent at this stage are mounted via the insulating substrate 2 on the metal base 1 and electrically connected to each other, thereby to form a circuit assembly. Then, the casing 5 is placed on this circuit assembly, fixed to the metal base 1, and then filled with sealing compound 6 injected through an injection hole formed at the top of the casing 5. The sealing compound is then hardened to seal the circuit assembly. Thereafter, the terminal nut 7 is mounted in the recess 5a whose upper portion is a polygonal hole substantially complementary to the outer shape of the terminal nut and whose lower portion is provided for receiving the end of a fixing screw (10 in Fig. 11).

Then the upper part of the terminal 4 projecting out of the top side of the casing 5 is bent into an L shape from the straight line state indicated by the chain lines in Fig. 10 to the position shown by solid lines, thereby creating the external wiring connection portion 4a overlying the recess 5a and the terminal nut 7 disposed in it. The numeral 4b denotes a hole drilled in the wiring connection portion 4a where a fixing screw is to be inserted.

The conventional terminal construction described above has the following problems because of a lack of mechanical strength.

That is, the wiring connection portion 4a has a cantilever structure supported at one end only, namely at the bending or corner of the L shape. Therefore, when a large tensile external force shown by arrow F in Fig. 11, is imposed on an external wiring 8 having a connecting terminal metal part 9 fixed to the wiring connection portion 4a by means of a fixing screw 10 and the nut 7 as shown in Fig. 11, the wiring connection portion 4a is pulled in a direction indicated by an arrow P (turned clockwise in Fig. 11) and deformed as shown. This may happen to an extent that the wiring connection portion 4a is lifted with the nut 7 pulled out from the recess 5a. Moreover, if a repeated load such as a vibration is imposed on the semiconductor device for an extended period of time when such a deformation has been caused, stress will be concentrated on the bent part of the terminal 4 , leading to a breakage of the terminal at the bent part because of elastic fatigue, which in turn can cause a serious failure of the semiconductor device as it becomes impossible to energize it.

The present invention has been made after considering these problems, with the intention of solving said problems, and its objective is to provide a terminal structure for such resin-sealed or potted semiconductor device with improved support strength against external forces acting on the external part of the terminal.

The above objective is achieved by a semiconductor device as claimed in claim 1.

Preferred embodiments of the invention are subject-matter of dependent claims.

In one embodiment of the invention an anchor that is bent downward is disposed on the tip of the terminal extending further from the external wiring connection portion, said anchor being fixed on the casing. The anchor may be fixed by inserting the tip of the anchor into the outer casing and embedding it in the sealing compound, or forming the tip of the anchor integrally with the outer casing by embedding it in the case lid that has been formed as a resin molding independent of the outer casing.

In another embodiment of the invention an auxiliary metal anchoring member is inserted between the terminal nut and the external wiring connection portion of the terminal, the leg of said auxiliary member being fixed on the outer casing. The auxiliary member may be fixed by inserting a leg of the auxiliary member into the outer casing and embedding it in the molded resin serving as sealing compound, or fixing the leg of the auxiliary member on the outer casing.

In still another embodiment of the invention a fixing means to prevent the terminal nut from being pulled off is used on the terminal nut, the terminal nut being fixed on the outer casing by said fixing means. The fixing means may be an integral part

of the nut which is provided below the terminal nut and inserted into the outer casing and embedded in the molded resin, or a wedge-like protrusion provided around the terminal nut, said terminal nut being press-fitted and fixed in the recess of the outer casing.

In the above embodiments, the external wiring connection portion of the terminal and the terminal nut, or the external wiring connection portion and the auxiliary metal anchoring member are bonded together by screwing the external wiring onto the wiring connection portion with a fixing screw. In each case the wiring connection portion is fixed to the casing at two points thereby increasing the strength of the support. Therefore, even if a large tensile external force is imposed on an external wiring connection portion of the terminal via the external wiring, undesirable deformation of the terminal and its floating away from the outer casing can be prevented, and trouble such as breakage of the terminal can be reliably prevented even if a repeated load such as a vibration is imposed.

Embodiments of the present invention are described below with reference to the accompanying schematic drawings, in which:

Fig. 1 (a) to (c)
illustrate a first embodiment of the invention with (a) being a fragmentary cross-sectional view of the semiconductor device, (b) being a perspective view of an upper part of the terminal and (c) showing a longitudinal section of the semiconductor device;

Fig. 2
is a cross-sectional view similar to Fig. 1(a), illustrating the terminal structure corresponding to a second embodiment of the present invention; Figs. 3 (a) and (b) illustrate a third embodiment of the present invention, with (a) showing in cross section the upper part of the semiconductor device in an assembled condition, and (b) showing a perspective view of a metal anchoring member used in this embodiment;

Figs. 4 (a) to (e)
illustrate modifications of the metal anchoring member for use in the third embodiment of the invention;

Figs. 5 (a) and (b)
are views similar to Fig. 3 of a fourth embodiment of the present invention;

Fig. 6
is a view similar to Fig. 5 (a) illustrating as a fifth embodiment a modification of the embodiment shown in Fig. 5;

Figs. 7 (a) and (b)
illustrate a sixth embodiment of the present invention, wherein (a) is a cross section of the upper part of the semiconductor device in an assembled condition, and (b) is a perspective view of the terminal nut;

Figs. 8 (a) to (e)
illustrate a seventh embodiment of the present invention, wherein (a) is a cross section of the upper part of the semiconductor device in an assembled condition, (b) and (d) are plan views of two different examples of a terminal nut and (c) and (e) side views corresponding to (b) and (d), respectively;

Figs. 9(a) to (c)
are a plan view, a longitudinal cross section and a side view, respectively, of a conventional resin-sealed semiconductor device;

Fig. 10
is a cross section illustrating the terminal structure of the device shown in Fig.9; and

Fig. 11
illustrates a deformation of the terminal of the conventional semiconductor device of Figs. 9 and 10 when an external force acts on the terminal.

In Figs. 1 to 8 parts identical to those in Figs. 9 and 10 are given the same reference numerals.

First embodiment:

Figs. 1 (a), (b) and (c) show a first embodiment of the invention which differs from the conventional device explained above mainly by having the terminal 4 equipped with a tongue-like anchor portion 4c formed and arranged to provide for a second support of the wiring connection portion 4a. The anchor portion 4c extends from the distal end of the wiring connection portion 4a, i.e. the end of the latter opposite to the end where it is bent from the lower part of the terminal 4. The anchor portion 4c is bent downward or back into the casing 5 through a hole 5b on the top of the outer casing 5. The free tip end of the anchor portion 4c is embedded and fixed in the sealing compound 6. Numeral 4d denotes an anchoring hole drilled at the tip of the anchor portion 4c.

The above structure is assembled in the following manner: After the circuit assembly is covered with the casing 5, the terminal 4 protruding from the top of the casing 5 is bent into an inverted U-shape with the wiring connection portion 4a forming the base of the U-shape and located outside of the casing 5 and the anchor portion 4c inserted into the casing 5. Then the sealing compound or resin 6 is injected into the casing 5 and hardened. Thus, the rising lower part of the terminal 4 and at least the tip end of the anchor portion 4c are embedded and fixed in the sealing compound 6. By providing an anchoring hole 4d in the anchor portion 4c, sealing compound 6 will flow through this anchoring hole 4d, thereby increasing the bonding strength. This allows the wiring connection portion

to be supported at two opposite sides, thus assuring a high support strength, and preventing the problems of the conventional semiconductor device mentioned above.

Second embodiment:

Fig. 2 shows a second embodiment of the present invention. In this embodiment, a case lid 11 made from resin separate from said casing 5 is provided on top of the casing. The terminal 4 has substantially the same structure as that of the first embodiment, however, in this case the upper part of the terminal 4 is formed integrally with the case lid such that, except for the wiring connection portion 4a, the upper part of the terminal 4 is embedded in the case lid 11. The case lid 11 is molded integrally with the terminal 4 and the terminal nut 7 before the terminal 4 is integrated into the circuit assembly and after the wiring connection portion 4a and the anchor portion 4c are bent and formed. A box nut is used as the terminal nut 7 to prevent resin from getting into the screw hole during the forming process. The terminal 4 now formed integrally with the case lid 11 is integrated into the circuit assembly, the circuit assembly covered with the casing 5 and the casing 5 filled with sealing compound 6, which is then hardened thereby securing the case lid 11 to the casing 5.

This construction improves the supporting strength of the terminal 4 to the same extent as that in the first embodiment described earlier. Moreover, such a construction makes it possible to bend the terminal 4 prior to integrating it into the circuit assembly, thus making the assembling efficiency higher than in the first embodiment.

Third embodiment:

Fig. 3 shows a third embodiment of the present invention. In this embodiment a separate metal anchoring member 12 which is bent into an L shape is inserted between the wiring connection portion 4a and the terminal nut 7. A bent leg 12a of this member 12 is inserted into the casing through a hole 5b in the outer casing 5 at a position opposite to where the terminal 4 comes out of the casing 5 and is embedded and fixed in the sealing compound 6 therein. Numeral 12b is a screw hole provided in the horizontal leg of the anchoring member 12 at a position registered with the terminal nut 7, and numeral 12c is an anchoring hole drilled at the tip of the leg 12a.

When the terminal 4 of this embodiment is connected to an external wiring in the same manner as in Fig. 11, the terminal 4 and the anchoring member 12 are joined together by the fixing screw (10 in Fig. 11) and the nut 7. This construction, which the leg 12a of the member 12 embedded and fixed in the sealing compound 6, serves to reinforce the terminal 4 to the same extent as in the previously described embodiments. Furthermore, a spring seat provided on the member 12 serves to prevent the fixing screw screwed into the terminal nut 7 from becoming loose.

Figs. 4 (a) through (e) show variations of the metal anchoring member 12 of Fig. 3. Notches 12d providing an equivalent anchoring effect are formed in place of the anchoring hole 12c in Figs. 4 (a) and (b), while irregular steps 12e are formed in Fig. 4 (c), and plural legs 12a are formed in Figs. 4 (d) and (e), each leg being provided with an anchoring hole 12c.

Fourth embodiment:

Figs. 5 (a) and (b) show a modification of the third embodiment, wherein the leg 12a of the metal anchoring member 12 is hook-shaped. The leg 12a is inserted into an opening hole 5b in the casing 5 such as to engage an inner surface portion of the casing thereby being fixed and preventing it from falling off.

In this embodiment, the member 12 serves to reinforce the terminal 4 to the same extent as in the previously described third embodiment. Moreover, since the member 12 can move slightly with respect to the casing 5, the positioning of the member 12 needs to be controlled less carefully than in the third embodiment.

Fifth embodiment:

Fig. 6 shows a modification of the fourth embodiment of Fig. 5. In this embodiment a hook 5c with a step to engage and fix the leg 12a of the metal anchoring member 12 is formed at the upper edge of the casing 5. Since this construction separates the hook 5c completely from the sealing compound 6 in the casing 5, then there is no danger for the anchoring member 12 to lose moveability because of contact with the sealing compound 6. This ensures that the screw hole 12b of anchoring member 12 can be easily registered with the nut 7.

Sixth embodiment:

Fig. 7 (a) and (b) show a sixth embodiment of the present invention, wherein an anchor portion 7a is integrally formed with the terminal nut 7 extending downward from the bottom side of the terminal nut 7. As in the previous embodiments the terminal nut 7 is disposed in a recess 5a on top of the casing 5. To mount the terminal nut 7, the anchor portion 7a is inserted into a hole located in the

bottom of the recess 5a. Upon filling the casing 5 with the sealing compound 6, the anchor portion 7a is embedded in and fixed by the sealing compound 6.

In the sixth embodiment, as soon as the external wiring is connected to the connection portion 4a by means of the screw 10 (see Fig. 11), the wiring connection portion 4a of the terminal 4 is held by the terminal nut 7 which in turn is fixed to the sealing compound 6 by means of the anchor portion 7a as described earlier. Thus, the supporting strength of the terminal is improved as in the case of the embodiments described above.

Seventh embodiment:

Figs. 8 (a) illustrates a seventh embodiment of the present invention which is a modification of the sixth embodiment and differs from the latter in the way the terminal nut is fixed to the casing 5. In this embodiment, protrusions 7b as shown in Figs. 8 (a) to (e) are disposed on the circumferential surface of the terminal nut 7, which is mounted in the recess 5a of the casing 5. In the configuration shown in Figs. 8 (a) and (b), inverse pyramid-like protrusions are formed on each side of the hexagonal nut. In the configuration shown in Figs. 8 (c) and (d), wedge-like protrusions 7b are formed in thread-like teeth.

In this embodiment when the terminal nut 7 is pushed or screwed (like a tapping screw) into the recess 5a in the casing 5, the wedge-like protrusions 7b dig into the wall of the recess 5a, fixing the nut 7 and, via the screw 10 (Fig. 11), the wiring connection portion 4a securely to the casing 5. Therefore, like the previous embodiments, this embodiment will prevent those problems to occur that have been described above with reference to Fig. 11.

By adopting a construction as in the above described embodiments of the present invention, the terminal can be reliably prevented from becoming excessively deformed and from being lifted off the outer casing, or from breaking due to a repeated load such as vibration, even if great external tensile force is applied to the external wiring screwed on the external wiring connection portion of the terminal. As a result, the product reliability can be greatly improved.

Claims

1. A semiconductor device having an outer casing (5) housing a semiconductor chip (3) and filled with a sealing compound (6), at least one terminal (4) bent into an L-shape of which one leg extends into the casing and is connected to the semiconductor chip (3) while the other leg forms an external wiring connection portion (4a) disposed outside of the casing substantially in parallel to a wall portion thereof, a recess (5a) formed in said wall portion beneath the wiring connection portion (4a), and a terminal nut (7) provided in the recess for connection of an external wiring (8, 9) to the wiring connection portion (4a) by means of a screw (10) passing through a hole in the wiring connection portion (4a) and screwed into the terminal nut (7), *characterized* by anchoring means (4c, 12, 7a) additionally fixing the wiring connection portion (4a) to the casing (5) at a position spaced apart from the corner of the L-shaped terminal (4).

2. The semiconductor device of claim 1, wherein the terminal (4) comprises an anchor portion (4c) provided at the end of the wiring connection portion (4a) opposite to said corner, the anchor portion (4c) bent downward and fixed to the casing (5).

3. The semiconductor device of claim 2, wherein the tip of the anchor portion (4c) is inserted into the casing (5) and embedded in the sealing compound (6).

4. The semiconductor device of claim 2, wherein said wall portion of the casing (5) is formed by a case lid (11) formed as a separate resin molding and fixed to the casing by means of the sealing compound (6), the tip of the anchor portion being integrally molded with the case lid (11).

5. The semiconductor device of claim 1, wherein said anchoring means comprises a separate anchoring member (12) inserted between the wiring connection portion (4a) and the terminal nut (7) said anchoring member (12) being fixed to the casing (5) and having a screw hole (12b) registered with the terminal nut (7).

6. The semiconductor device of claim 5, wherein said anchoring member (12) is substantially L-shaped with a leg (12a) inserted into the casing (5) and embedded in the sealing compound (6).

7. The semiconductor device of claim 5, wherein said anchoring member (12) has a hooked end (12a) engaging a retaining edge of the casing (5).

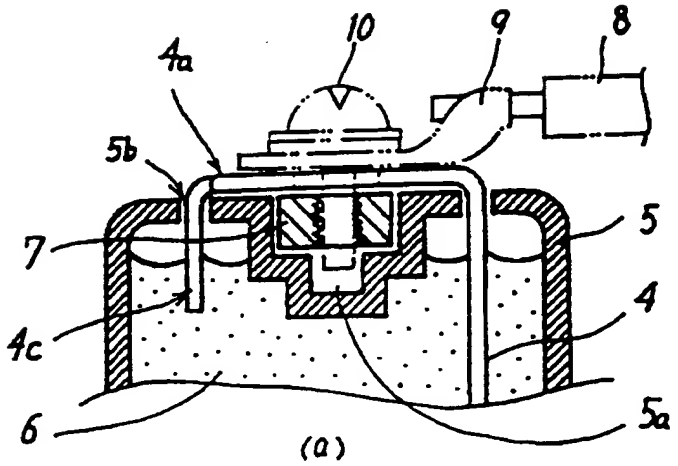
8. The semiconductor device of claim 1, wherein said anchoring means comprises means (7a) for fixing the terminal nut (7) to the casing and

preventing it from being pulled off said recess (5a).

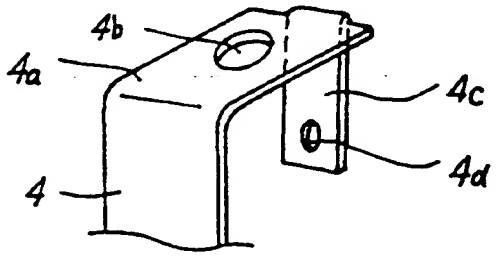
9. The semiconductor device of claim 8, wherein an anchor portion (7a) integral with the terminal nut (7) is provided at the bottom side of the terminal nut, said anchor portion being inserted into the casing (5) and embedded in the sealing compound (6).

10. The semiconductor device of claim 8, wherein one or more wedge-like protrusions (7b) are provided around the terminal nut (7), the terminal nut (7) being fixed to the casing (5) by being press-fitted into said recess (5a).

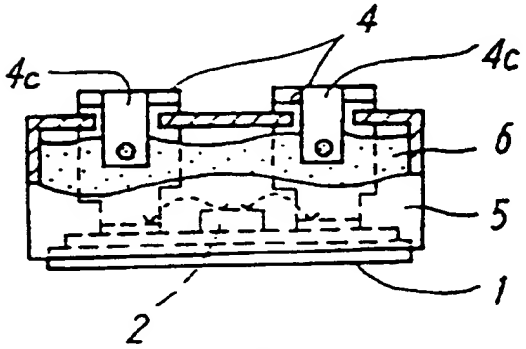
FIG. 1



(a)



(b)



(c)

FIG. 2

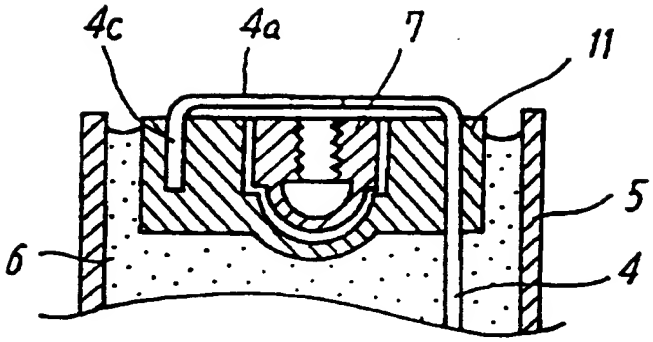


FIG. 3

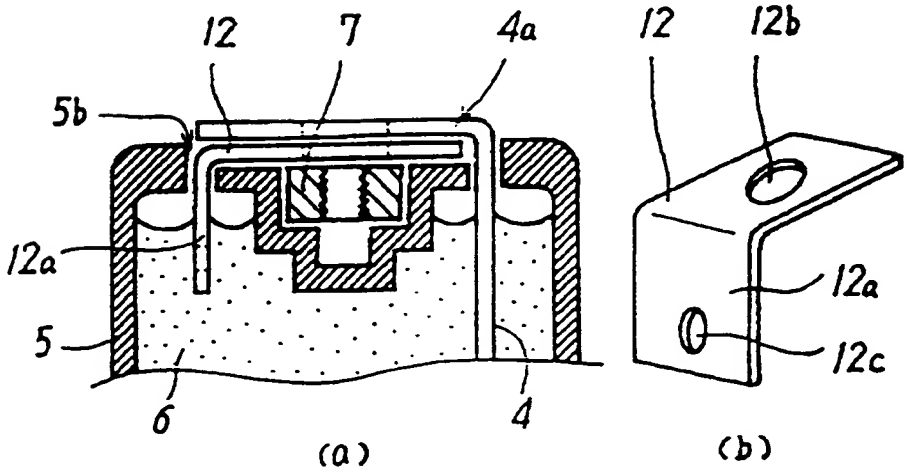


FIG. 4

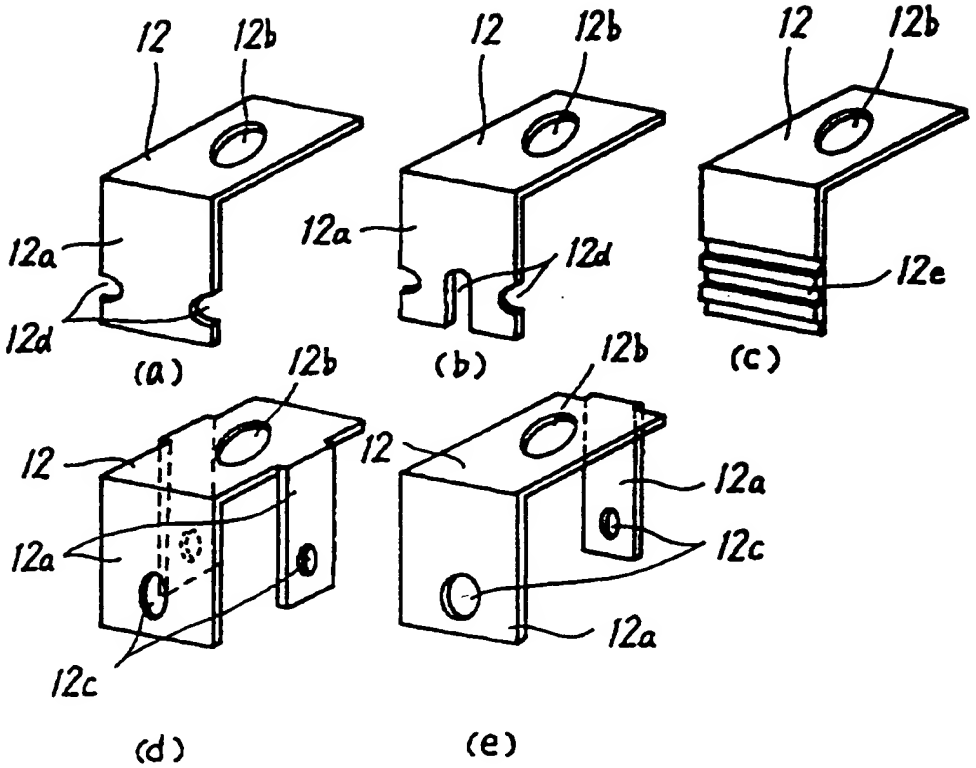

12
12b
12a
12d
(a)
12
12b
12a
12d
(b)
12
12b
12e
(c)
12b
12
12a
12c
(d)
12b
12
12a
12c
12a
(e)

FIG. 5

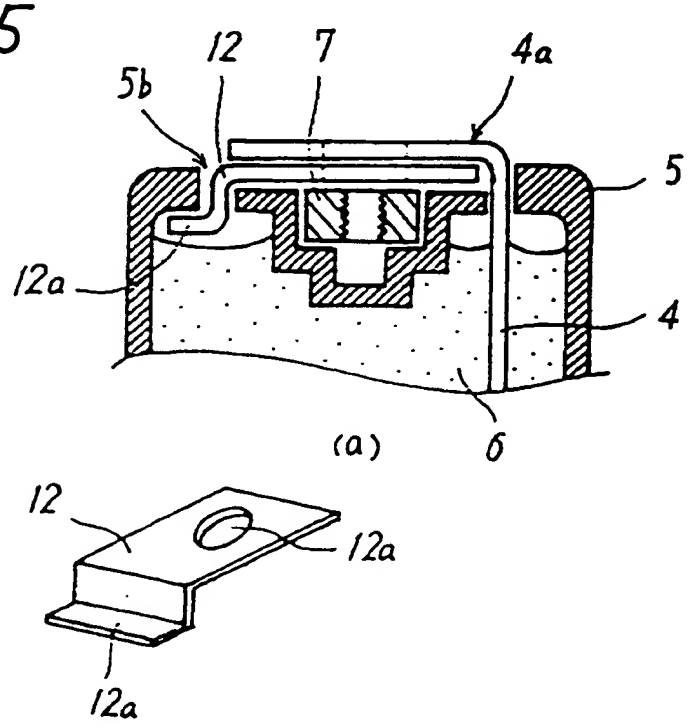

12
7
4a
5b
5
12a
4
6
(a)
12
12a
12a
(b)

FIG. 6

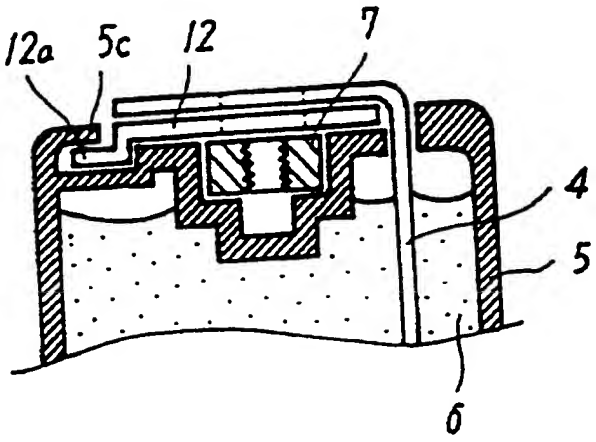
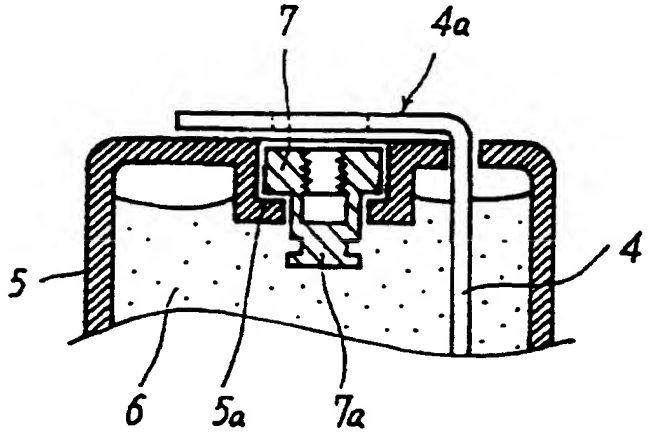
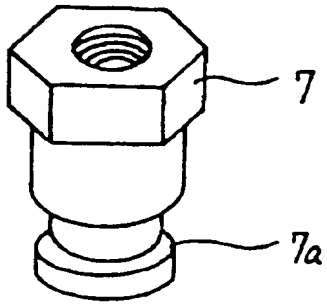


FIG. 7

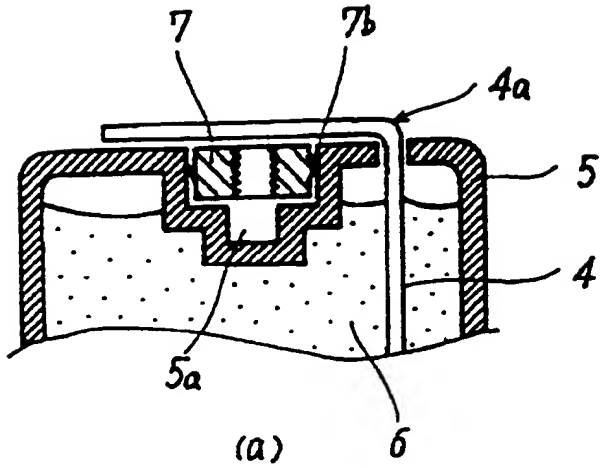


(a)

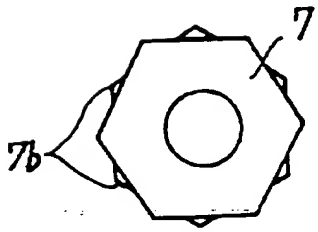


(b)

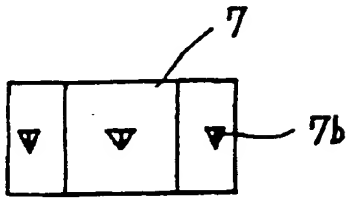
FIG. 8



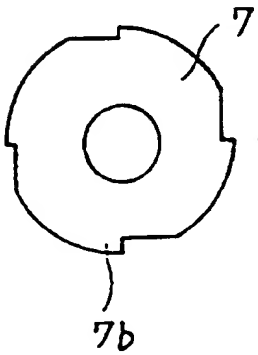
(a)



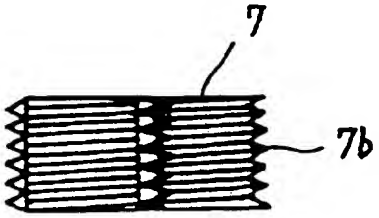
(b)



(c)

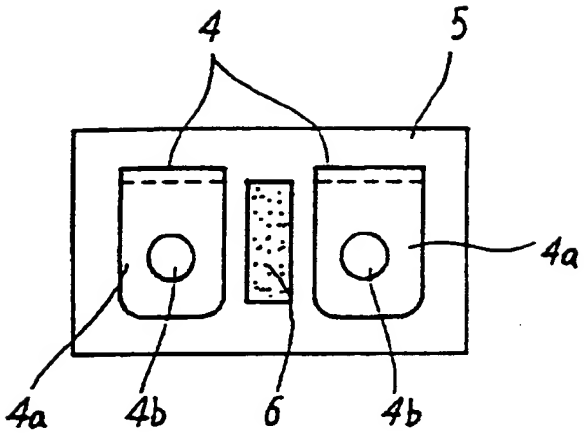


(d)

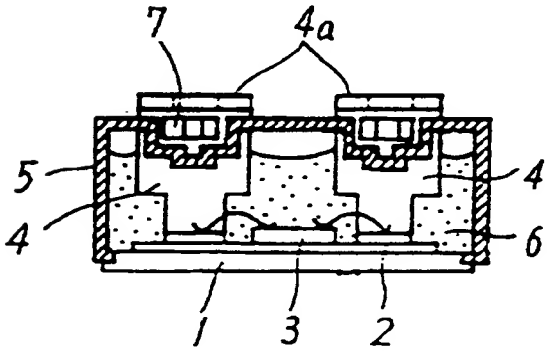


(e)

FIG. 9



(a)



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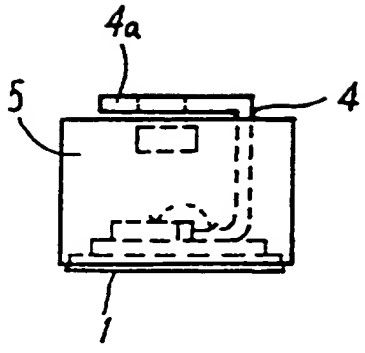

(c)

FIG. 10

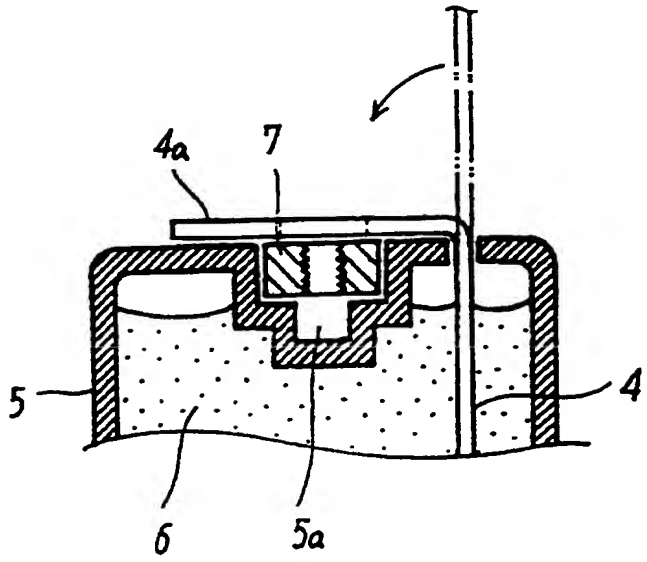

FIG. 11